F.R.S. Messrs. Blackie will publish a new edition of Thompson's "Gardener's Assistant, Practical and Scientific," revised and extended by Thomas Moore, F.L.S., Curator of the Chelsea, Botanic Gardens, &c., assisted by several eminent practical gardeners; also "Upper Egypt, its People and its Products," a descriptive account of the manners, customs, superstitions, and occupations of the people of the Nile Valley, the Desert, and the Red Sea Coast, with sketches of the natural history and ecology, by C. B. Klunzinger, M.D., formerly Egyptian Sanitary-Physician at Koseir on the Red Sea. Mr. Maclehose, of Glasgow, announces: "Outlines of Physiology," by Prof. McKendrick; Messrs. Collins: "Building Construction," by R. Scott Brown; "Machine Construction," by E. Tomkins; and "Mineralogy," by J. H. Collins, in their Advanced School Series.

IN a paper in the *Journal de Physique*, on the spectrum of the electric spark, by M. Cazin, the author concludes that the electric spark in a gas contains incandescent gas particles, which give a bright line spectrum, and solid and liquid particles which produce the continuous spectrum, the former coming from the gaseous medium and the electrodes, the others from the electrodes and the sides near the spark. If the pressure increases, the solid or liquid particles become more abundant, and their continuous spectrum predominates; at last this makes it impossible to distinguish the bright gas lines, or, in other words, the latter, while the pressure increases, seems to dilate, and eventually flow together into one continuous spectrum. By making photographs of the spectra M. Cazin found his views confirmed. Of the nitrogen spectrum at ordinary pressure he photographed sixty-two lines, using nine cells in the battery giving the spark.

HERR J. STEFAN has lately communicated the results of some interesting researches to the Vienna Academy of Sciences, relating to the heat-conducting power of several substances. The conducting power of copper being taken as unity, he found that of iron to be 0·17, ice 0·0057, glass 0·0016, water 0·0015, hydrogen 0·00039, hard india-rubber 0·00026, and air 0·000055.

IN a recent communication to the Vienna Academy M. Ciamician discusses the spectra of chemical elements and their compounds. He finds, in agreement with Lockyer, that the compound spectra, as well as those of the first order of the elements, consist exclusively of bands; and further, that band-spectra belong to molecules and molecular groups, line-spectra to free atoms. From a comparison of the spectra of thirty-one elements he draws these conclusions: 1. The spectral lines of chemically-allied elements correspond to each other either individually or group-wise, so that each natural group of elements has its own spectrum, which, in the individual members of the group, is different only in that the homologous lines are displaced towards the one or the other end of the spectrum, *i.e.*, increase or decrease in wave-length, and that certain lines or line-groups disappear. 2. The increase or decrease of wave-lengths of homologous lines in chemically-allied elements depends on the intensity of their chemical *vis viva*, a greater wave-length corresponding to a greater chemical *vis viva* of the particular element.

ALTHOUGH for years there has been no scarcity in France through drought, still the want of irrigation is much felt almost every summer in the departments of the Mediterranean region. The French Government is about to take measures which might serve as a hint to the Indian Government. A project is being considered for taking advantage of the waters of the Rhone to irrigate systematically that large and already fruitful country. It is impossible to foresee what wonderful changes may result from such a scheme, which it is contemplated to bring into speedy execution.

THE Annual Report of the Queensland Philosophical Society, 1877, just received, is a satisfactory one. It contains the address of the president, Sir James Cockle, on some of the aspects of the evolution theory.

THE second volume, for 1877, of Dr. Emilio Huelin's "Cronicon cientifico popular," has just been published at Madrid. In a recent number we gave a short notice of the first volume. The second volume is in every respect equal to the first.

THE additions to the Zoological Society's Gardens during the past week include two Bonnet Monkeys (*Macacus radiatus*) from India, presented by Mr. T. Golding and Miss Ward; a Layard's Flying Squirrel (*Sciuropterus layardi*) from Ceylon, presented by Sir Charles Peter Layard; a Brown Coati (*Nasua nasica*) from South America, presented by Dr. G. P. Best; a River Jack Viper (*Vipera rhinoceros*) from West Africa, presented by Mr. I. J. Kendall; two Red Kangaroos (*Macropus rufus*) from Australia, four Chinese Turtle Doves (*Turtur chinensis*) from Java, deposited; a large-billed Crow (*Corvus culminatus*) from India, purchased; a Vulpine Phalanger (*Phalangista vulpina*), born in the Gardens.

THE LIMITS OF NATURAL KNOWLEDGE[1]

THE subject of my address was excellently treated at the Leipzig meeting in 1872, by Prof. Du Bois Reymond. If I take up the same matter again, I do so because I would consider it from a somewhat different and more universal point of view.

I shall also depart from the form and language in which the subject has hitherto been frequently treated. In its generality the theme easily induces the speaker to make excursions into the philosophical domain and to adopt the corresponding manner of expressing himself. I shall use words only of the simplest and clearest description, and I shall not suppose my hearers possessed of anything but a knowledge of the most elementary phenomena in the various domains of nature. In general matters expression is all the simpler and the more intelligible the closer our ideas approach clearness, and, at the same time, truth. I think it advisable, before entering upon the subject itself, to mention shortly the different ways in which the question of the limits of natural knowledge is generally conceived and answered by naturalists.

Amongst the so-called practical scientific men (*Praktiker*) the view is widely spread that a certain and lasting knowledge and understanding of natural phenomena is, on the whole, impossible. They know that hitherto their systems and opinions have not been permanent, and think that scientific theories generally are only attempts to approach the inaccessible reality, attempts which change their tenor and expression with the views of the time. This is evidently not a view based on principles, but only despair caused by failure, the necessary consequence of wrong method and of scientific incapacity.

The practical scientific man relies upon his experience, as he says. This, however, is gained in the following manner:—Each natural phenomenon is accompanied by different and often numerous causes and other circumstances. It is the task of the investigator to find out what are the effects of each one of these causes and circumstances; and this task cannot, in most cases, be accomplished by mere observation. The practical man then selects some cause or circumstance which happens to appear conspicuous to him, and in this he finds the fundamental cause of the phenomenon. This he calls his experience. We therefore understand how these practical men may hold different opinions upon the same phenomenon, why their views bear the stamp of the scientific epoch, and why in course of time they change. We also understand why the theories based on so-called experience are most fertile in those domains where phenomena are most complicated, as in organic morphology, in physiology, and pathology.

[1] Address delivered at the Munich meeting of the German Association, by Prof. C. von Nägeli, of Munich. (The author, in a note to the German original, remarks that this lecture had to replace another in the programme, which had been promised by Prof. Tschermak, of Vienna. At the eleventh hour Prof. Tschermak announced his inability to attend the Munich meeting, and the author was requested by the secretaries to fill the gap thus occasioned. The address therefore, the author states, bears the stamp of its hasty origin, as it was written during a journey in the Alps, when there was neither sufficient leisure nor opportunity for careful and elaborate work.)

The problem of a natural phenomenon is an algebraic equation with many unknown factors. The practical man looks at the equation and tries to solve it, substituting for one or the other unknown factor a generally large and decisive value; the proof of correctness he does not attempt. It is easy to see that in this manner the solution—and with it the true understanding—will certainly not be attained in all eternity.

The solution of an equation with many unknown factors is only possible if just as many equations can be obtained as there are unknown factors, and if the same unknown factors are contained in all. As this is generally impossible with natural phenomena we try to get equations in which there is only *one* unknown factor. This is done by *scientific* experiment (not by the so-called experiment of these practical men) in which all unknown factors are removed save one, and by which the value and effect of this one can be securely determined.

For a long time physics has adopted this way of scientific experiment. Physiology has only recently recognised it in a more general manner as the only correct one. It is true that by this tedious and time-devouring but yet exclusively safe and progressive method we do not erect large edifices of systems which are only fated to fall to pieces again shortly, but we gain simple facts, perhaps insignificant by themselves, but which retain their value for ever and enable us to find new facts. Thus the stock of recognised facts increases slowly but securely. A snail which takes the straight road for its goal progresses, while a grasshopper, with its bounds in all directions, remains always on the same spot. Thus scientific investigation proves to the empirics by facts, that by the exact method certain and permanent knowledge of natural phenomena may be gained.

Many methodical investigators who by the exact method augment the stock of permanent facts, when asked for the limits of natural knowledge, and thinking a solution based upon principles inadmissible, simply reply, "Belief always begins where knowledge ceases." In saying so the course of their thoughts runs thus: Humanity faces the totality of nature. Its insight constantly masters new domains by dint of meditation and investigation. Thus, for example, in the present time we have progressed much further in the knowledge of nature than was the case during the middle ages and antiquity, and European civilisation is far ahead of that of the rest of humanity. With progressing mental work the empire of knowledge always increases in extent, and the domain where we must be satisfied with belief decreases as constantly.

This conception has an undeniable value in a certain regard. It gives us a measure of the height which scientific natural knowledge had generally attained in every century, and at the same time a special measure for the different human races and nations, for the different classes in a nation, and finally for every single individual. Considerations of this nature have as much scientific interest to the historian and anthropologist, as practical interest to the theologist, the politician, and a number of others.

The phrase that belief begins where knowledge ceases is an actual solution of the question for certain ends. But with this our interest is not satisfied. We turn to the theoretical part of the problem with special sympathy. We wish to know whether the limit where human knowledge must stop can be determined at all or not—if yes, how far our understanding may penetrate into nature, how much humanity may scientifically understand of nature, if during an immeasurable period, let us say at once during eternity, it is occupied with natural investigations, assisted by all imaginable means—what are the boundaries, therefore, which the scientific understanding of nature can never and under no conditions overstep? what is the fundamental limit between the empire of knowledge and that of belief?

This question deserves all the more to be seriously investigated since it is well known that from two opposed sides the absolute power of the human mind over nature is claimed with complete certainty—with decreasing energy by the natural philosophers, with increasing energy by materialists. The former think they can construct formal nature out of herself, and natural knowledge for them only consists in finding the concrete natural phenomena for the constructed abstract ideas, where, of course, they can in no point be freed from the self-deception that they construct the ideas according to conceptions by the senses instead of out of themselves. The latter admit only force and matter in time and space; and that man, who is built up of matter and force, shall master nature, which is built up of the same factors, seems to them a reasonable idea. Both, natural philosophers as well as materialists, raise man to a flattering height, with regard to his own consciousness and pride; they declare him lord of the world, not the real lord who makes the world, it is true, but yet the imaginary lord, who understands the work of the real lord. Can we lay claim with good reason this eminent position?

Many have often tried to answer this question from different points of view; perhaps one of the best replies was given by my predecessor in this assembly, Prof. Du Bois Reymond, in his much-talked-of and often misunderstood address, "On the Limits of Natural Knowledge." I shall only consider this latter reply, which, in an intellectual manner and in rich, poetical language, adorns and covers the gems of thought with the most beautiful flowers of speech. It would have been useful, and would have shown the right way to many a one who cannot so easily get at the kernel through the shell, if result and proof had been comprised in a few short phrases.

The speaker, like the conqueror of a world in the olden times on a day of rest, wishes to point out clearly the true limits of the immeasurable empire which world-conquering natural science has subjected to its understanding, and arrives at the following three conclusions:—1. Natural knowledge, or understanding, is the reduction of a natural phenomenon to the mechanics of simple and indivisible atoms. 2. There are no atoms of this description, and therefore there is no real understanding. 3. Even if we could understand the world through the mechanics of atoms, we could nevertheless not understand sensation and consciousness through it.

General understanding would no doubt have been facilitated considerably if these results had not been introduced as the limits of natural knowledge, but as the impossibility and futility of natural knowledge. Because, since the speaker does not go beyond this negation, investigating natural science cannot define the limits of a domain which she does not even possess—and if she is even deprived for ever of all insight into material phenomena, it can hardly matter to her, as a deposed potentate, whether or not she might claim the spiritual domain, in case of a supposed accession to power.

We may perfectly agree with Du Bois Reymond's thoughts, and yet be convinced that they are not complete and all-comprising enough to define natural knowledge in all directions, that in their incompleteness they lead to false deductions which contradict our natural scientific conscience, and that it is desirable to treat this question not only on the negative side, but to examine whether the human mind is not capable of natural knowledge, of what nature this knowledge is, and what is its extent.

The solution of the question: In what way and how far may I know and understand nature? is evidently determined by three different things, viz., by the answers to three questions:—(1) The condition and capacity of the Ego; (2) the condition and accessibility of nature; and (3) the demands which we make of knowledge. Subject, object, and copula therefore participate in the solution. A separation of this kind may perhaps be thought superfluous, perhaps even inadmissible, because it may be said that the understanding of the object by the subject is an indivisible process. And yet it is correct, because consideration gives prominence now to the one and now to the other factor, and it is also useful, because it requires exhaustive treatment. The difficulties which are in the way of knowledge with regard to the subject or object, are even most conspicuous if we entirely remove one of the two factors by supposing that it offers no difficulties at all. With regard to the capacity of the Ego to understand the phenomena of nature, the undoubted fact is decisive, that our power of thinking, in whatever condition it may be, only gives us nature as we perceive her by our five senses. If we could not see nor hear anything, nor smell, taste, nor touch anything, we would not know at all that there is anything besides ourselves, nor indeed that we are in bodily existence ourselves.

The condition with regard to the correctness of our conceptions therefore always exists—that our external and internal senses report correctly. Our knowledge is only correct in so far as observation by the senses and internal perception (*die innere Vermittelung*) are correct. But an infinitely great probability exists that both, after all, lead us to *objective* truth, because the errors committed by the single individual or by all, are finally always recognised and proved as such, and because natural science, the further it progresses, knows how to remove more and more all apparent contradictions, and how to make all observations agree amongst themselves.

If we remain satisfied in this direction, the question arises,

to what extent and in what fulness the senses acquaint us with natural phenomena. With regard to the extent we need only point out the boundaries in order to make them perfectly clear to everybody. In time only the present and in space only that which belongs to our own circumstances is accessible to us. We cannot directly perceive anything of what happened in the past, and of what will be in the future, and nothing that is too distant in space, or that is of too large or too small dimensions.

With regard to the completeness of sensual perceptions there is another boundary which is generally not thought of, and upon which I must enter a little more in detail. Scientific analysis shows the following:—In the totality of force-endowed matter, which we call world, each particle of matter by all its inherent forces is in relation with all others; it is influenced by all, and in its turn acts upon all, of course according to distances. A conglomeration of particles of course behaves like a single particle; the effect which it causes and receives is the total of the effects of all single particles. The crystal, the plant, the animal, man are acted upon by the presence of all material particles, of each single one by itself and of each conglomeration of particles, and this with reference to all forces which are inherent in them, and consequently with reference to all movements which they perform. But these effects in the infinite majority of cases are so insignificant that they may be neglected as quite imperceptible.

The *theoretical* possibility therefore exists that the human organism may obtain bodily perceptions of all phenomena in nature. But how is this matter in *reality?* What impressions are so powerful that they become perceptible to us, and which of them are lost, being too insignificant? Amongst the beings known to us, man and the higher animals have the advantage, that certain parts have developed themselves into organs of sensation, which are extremely sensitive for certain natural phenomena. These organs of sensation, in the course of numerous and successive species and of innumerable generations within each single species, have been developed from the smallest beginnings to high degrees of perfection.

The ingenious idea of Darwin that in organic nature only such arrangements attained full development which were useful to the individual bearer, is so simple, so reasonable, and agrees so well with all experience, that physiologists, who alone are competent to decide here, agree with him perfectly, and are greatly astonished, that a Columbus should not long ago have placed this physiological egg upon its point.

The degree of perfection which each organ of sensation has attained in development therefore corresponds exactly to the requirements, and there is not one in which the human organism is not far surpassed by some animal species, if to the latter the extraordinary fineness of some particular sensual perception became a condition of its existence. But according to this both the human and animal organisms have only developed organs of sensation for such external influences as bear upon their existence in a favourable or unfavourable sense.

We are endowed, for instance, with great sensitiveness for temperature; it is necessary for our existence, otherwise we might perish through cold or heat without knowing it. We are very sensitive towards light; it acquaints us in the best and quickest manner with all objects which surround us and which may be useful or dangerous to us. On the other hand we are not organised to perceive the electricity which surrounds us. While we perceive the increase or decrease of heat and light, we do not know whether the air in which we breathe contains free electricity or not, whether this electricity is positive or negative. If we touch a telegraph wire we cannot feel whether its particles are electrically at rest or in motion.

It was of no use that the sense for electricity should be developed particularly in man and the higher animals, because it is immaterial for the species whether every year some individuals were killed by lightning or not. If this danger were daily to threaten all individuals, the sense for electricity which the lowest animals possess in its first beginnings in the same degree as they possess those for light and heat, would necessarily have developed itself further. We would then perceive by a special organ of sensation the vicinity of a substance in electric tension and be able to escape the stroke of lightning. We would perceive small changes in the electric state and weak electric currents in our vicinity, and also be able to peer into the secrets of the telegraph wire. The want of such an organ might easily have been the cause of our total ignorance of electricity. We can very well imagine the atmosphere of the earth without lightning and thunder. These great electric discharges have helped us to the knowledge of electricity. If accidentally they had not happened, if, moreover, some quite accidental experiences which revealed an attractive and repulsive force generated by friction had not been made, we very probably would have had no idea of electricity, no idea of that force which doubtless plays the greatest part in organic and inorganic nature, which materially affects chemical affinity, which in all molecular motions in organised beings acts perhaps more decisively than any other force, and of which with regard to still mysterious physiological and chemical phenomena we expect the most important explanations.

Our senses are indeed only organised for the requirements of our bodily existence but not to satisfy our intellectual cravings,—to acquaint us with all phenomena of nature and explain them as well. If at the same time they perform this function it is only incidentally. We therefore cannot rely upon our sensual perceptions acquainting us with *all* phenomena of nature. Just as in the case of electric phenomena, which occur in every material particle, we have, as it were, learnt something only accidentally, it is easily possible, indeed very probable, that there are still other natural forces, other forms of molecular motion, of which we obtain no sensual impressions, because they never unite to any remarkable outcome, and therefore remain hidden to us.

Our power of perceiving nature directly by our senses is therefore very confined in two aspects. On the one hand we are probably deficient of the power of sensation for whole domains of natural life, and on the other, as far as we really have this power it is confined in time and space to an insignificantly small part of the whole.

It is true that our natural knowledge is not confined to what we perceive with our senses. By conclusions we may also obtain knowledge of what our senses do not reach. The farthest planet of our solar system, Neptune, was known by calculation with regard to its position, its size and weight, before astronomers had discovered it with the telescope. We know, although we cannot see it with the best microscopes, that water consists of infinitesimal particles or molecules which are in motion, and if it is sugar-water or salt-water, we know perfectly the proportionate weight and the proportionate number of the water, sugar, and salt particles of which it is composed.

By conclusions from facts which were recognised by the senses, we arrive at facts equally certain which can no longer be perceived by the senses. We might therefore, perhaps, indulge in the sanguine hope that starting from the small domain which is opened to us by our senses, little by little the entire domain of nature will be conquered by reason. But this hope can never be fulfilled. As the effect of a natural force decreases with its distance, the possibility of knowledge also decreases as the distance in space and time increases. Of the condition, the composition and the history of a fixed star of the least magnitude, of the organic life upon its dark satellites, of the material and spiritual movements in these organisms we shall never know anything. In the same way the possibility decreases of discovering a still unknown natural force, a still unknown form of motion of the smallest material particles, the less this force or motion possesses the peculiarity of accumulating and causing some collective effect. We may consider ourselves fortunate if ever we obtain only a notion of such a force.

The confined capacity of the Ego therefore allows us only an extremely fragmentary knowledge of the universe.

We now pass from the consideration of the subject to that of the object, *i.e.*, the condition and accessibility of nature. The boundaries, which nature herself opposes to our knowledge, are most evident if we adopt the hypothesis that man, on his side, has the most perfect capacity for natural knowledge. This would be the case if the obstacles of time and space did not exist for him, if he could judge of every phenomenon in the past as well as he can of everyone in the present; if the most distant object did not present more difficulty to him than one in his immediate vicinity, and if he could as easily survey the largest systems of fixed stars and the smallest atoms, as he can a body of his own size; if finally he were provided with senses so perfect that all phenomena of nature, all forces and all forms of motion could be perceived directly by him.

A human race, provided with these perfections, might perhaps be enabled to try the solution of Laplace's problem. Laplace says: "A mind, which for a given moment knew all forces which are active in nature, and the respective positions of the beings of which she consists, if it were comprehensive enough to analyse these data—would unite in the same formula the motion of the largest heavenly body and of the lightest atom. Nothing

would be uncertain for it, and the future as well as the past would be present to its gaze. The human mind, in the perfection which it has been enabled to give to astronomy, offers a weak reflection of a mind of this description."

But even a mind as universal as that supposed by Laplace would not be able to solve the problem given. Because the other supposition, of which Laplace does not speak, but from which he starts unconsciously, is the finiteness of the world in all directions, and this is not given. The difficulty which nature opposes to human knowledge is her *endlessness*, endlessness of space and of time, and of everything which depends on this as a necessary consequence.

In space nature is not only infinitely large; she is endless. The ray of light travels through some 190,000 miles in one second; to travel through the whole known universe of fixed stars it would require some twenty million years according to a probable estimate. Let us place ourselves in thought at the end of this immeasurable space, upon the farthest fixed star known to us, then we would not look out into empty space there, but we would see a new starry firmament. We would again believe that we were in the middle of the universe, in the same way as now the earth appears to us as the centre of the universe. And thus we may in thought continue endlessly the flight from the farthest fixed star to the farthest fixed star, and the actual starry heavens we now see, compared to the universe, are after all still infinitely smaller than the smallest atom compared to the starry heavens.

What applies to space applies equally to grouping in space, to the composition, organisation, and individualisation of matter, which is the object of descriptive and morphological natural science. Everything we know consists of parts, and is in itself part of a bigger whole. The organism is composed of organs, these of cells, and the cells of smaller elementary particles. If we analyse further we soon get to chemical molecules and the atoms of chemical elements. The latter certainly still resist further sub-division at present, but we must nevertheless look upon them as compound bodies on account of their properties. Thus in thought we may continue sub-division further and endlessly. In reality no physical atoms in the strict sense of the word can exist, no little particles which would really be indivisible. All size, indeed, is only relative; the smallest body in existence which we know, the particle of the light-and-heat ether may be of any size we choose for our conception, even infinitely large, if only we imagine ourselves to be sufficiently small by the side of it. Just in the same way as *indivisibility* never ceases, we must suppose, by analogy of what we find confirmed in the whole domain of our experience, that the *composition* also of individual particles separated from one another, continues endlessly downwards. In like manner we are forced to suppose an endless composition upwards in always larger, individual groups. The heavenly bodies are the molecules which unite in groups of lower and higher orders, and the whole of our system of fixed stars is only a molecular group in an infinitely larger whole, which we must again suppose to be a unit (*einheitlicher*) organism, and only a particle of a still larger whole.

As space is endless in all directions, so time is endless on two sides; it has never begun and will never cease. The Bible says: "In the beginning God created heaven and earth," and geologists say: "In the beginning the world was a gaseous mass, from which heavenly bodies formed by condensation." But this beginning is only a relative one, the beginning of a finiteness, and the time which has passed since this beginning is only as a moment compared to the eternity before.

From the union of time and space an empire of phenomena results, which forms the contents of descriptive natural sciences as well as of the other part of the investigation of nature, viz., the physical and physiological sciences. Matter, which fills space, is not at rest but in motion, and as the material particles act upon one another with different (attractive and repulsive) forces, each body which moves causes the others to move as well, or rather it changes their motions. It gives off a part of its motion and of its potential energy to others, and these again to others, and so on. This is the chain of cause and effect, also an endless one, as in our conception it neither could begin with a first cause nor can finish with a last effect.

Nature is everywhere uninvestigable where she becomes endless or eternal. We cannot, therefore, conceive her *as a whole*, because a process of conceiving which has neither beginning nor end, does not lead to conception. And this is the reason why Laplace's problem is futile from the beginning. Of course we are permitted to make any supposition we like, even one which for some reason or other is impossible, but not one which is unthinkable. But a formula is unthinkable for which we have not even got the component factors, and which if these factors were given, would never come to an end. The knowledge of *all* forces, which is required for Laplace's formula, supposes that the bodies are subdivided down to their last force-endowed particles, and this is impossible on account of divisibility being endless. The elements therefore are wanting, from which we might compose the formula, viz., the simple natural forces; we cannot even begin with the setting of the formula —and even if we could begin with it we could never come to an end with it on account of the endlessness of the universe in space. Du Bois Reymond has already mentioned the former endlessness as an insuperable limit; even if we could overstep it, the other would still prove equally insuperable.

If indeed the formula of Laplace comprised only the universe known to our senses, or even one infinitely larger (but not one really endless), and if we could introduce into this formula the forces of the known chemical elements and of the supposed ether particles, or even of much smaller material particles, then it might perhaps suffice for long periods of time backwards and forwards from the present, particularly for the middle of the system and for the greater phenomena. But on the one hand disturbances from the circumference would at once necessarily take place, and these would at last render the formula useless for the middle also; on the other hand, disturbances would begin on each single point as well, and as they would increase constantly, they would at last lead to perceptible inaccuracies, because the supposed "atoms," are not real unities, and because the resulting force, with which each single "atom," as a body composed of separate particles, influences the totality, does not remain a constant one, but with its varying surroundings assumes at every moment an equally varying value. Anyhow, a formula of this kind would give us, as astronomical calculation really does, a solution, correct within certain limits, a practical solution, but not a fundamental one.

The investigator of nature must remember distinctly, that all his investigations are confined by limits in all directions, that on all sides uninvestigable eternity bids him categorically to stop. The fact that this has not always been clearly recognised, that particularly the Infinitely Large and the Infinitely Small have been mixed up with Endlessness and Nothing, has led to several erroneous conceptions. Amongst them are the theories of physical atoms in the one direction, and those of beginning and end of the universe in the other. I will only speak of the latter.

It is supposed that the matter constituting the heavenly bodies was in the beginning distributed in a gaseous state; and in this Du Bois Reymond only finds one difficulty: if this matter, as the theory demands, had been at rest and distributed equally, he cannot find out whence motion and unequal distribution have come.

Condensation of matter has now gone on for an infinite time, *i.e.*, since that supposed beginning, and the results are first nebulæ, then burning-liquid drops, which cool down to dark bodies. In the present we are upon one of these condensed, and no longer incandescent world-drops. According to the natural laws known to us, the still incandescent and the already dark heavenly bodies must continue to give off their store of heat to universal space. By and by they must fall upon one another, and even if then a local rise in temperature again takes place, this after all only serves to accelerate the process of cooling on the whole. At last all heavenly bodies will unite in a dark, solid, icy mass, upon which there is no longer any motion nor life.

This is the result of a correct physical consideration. It shows us the desolate end of a present full of change and motion and glowing with life and colour. But in reality this result is only the consequence of our confined human insight; it would only be a logical necessity if we knew *everything*, and therefore were allowed to use our knowledge for deductions with regard to the beginning and end. But as we see only an infinitesimal part of the universe, and possess only a fragmentary knowledge of the forces and forms of motion in this infinitesimal part, our deductions backwards and forwards may perhaps for certain general conditions be without perceptible error for billions of years, but yet, with the lapse of greater periods of time, they must become more uncertain, and eventually totally erroneous. We may illustrate this particularly well with regard to the past.

What we are most certain of, with regard to the past, is the incandescent state in which our earth was at one period, and from this we draw the conclusion by analogy that the other planets of

our system were incandescent bodies as well, just as the sun is still to-day. If we go backwards from these suns we get, by further conclusions, to accumulated masses of clouds, the embryos of the later suns, then to cloud-belts, and eventually to the gaseous mass distributed tolerably uniformly, and this is the original state beyond which, with our present insight, we cannot get.

All this proves distinctly that just as upon the earth an eternal change takes place, the heavens likewise are constantly changing. Each change consists of a sum of motions, and supposes a former change or sum of motions, from which it resulted with mechanical necessity, and further on a chain of changes from all eternity. Thus the gaseous state of our solar system must have been preceded by a continuous endless series of changes, and if our scientific insight does not lead us to this, does not even justify us in this supposition, it thus proves only its own inadequacy.

We must, on the contrary, conclude from the eternity of changes in the universe that the whole process of development of our solar system or of the whole starry heaven, from the original gaseous mass, through the ball-shaped nebulæ, fiery and dark globes, to the cold, solid, and dense mass, is only one of the numberless successive periods, and that analogous periods and occurrences have preceded and will follow endlessly. It is true that we perfectly understand, according to our present physical knowledge, how a mass of gas in a state of progressing condensation produces heat, and how the hot condensed mass again gives off this heat until its temperature and that of its surroundings, in our case that of universal space, have become equal. But we do not understand how the solid mass can again become gaseous, and how the necessary heat, distributed in universal space, can again be collected.

There is a gap in our knowledge at this point; and we may fill it by various suppositions. In the present state of almost complete ignorance among physicists and chemists of the properties of chemical elements and of ether, it is possible that, with sufficient condensation of matter and approach of its particles, forces become active of which we have no idea at present, and which may perhaps bring about an explosive dispersion of the solid mass into a gaseous state. It is also possible that the quantity of heat in the endless universe (not in our starry heaven) is distributed unequally, and that there are domains in it which are of a much higher, and others which are of a much lower, temperature than our starry heaven; that in the endless space of the universe heat currents exist, similar to the air currents in our atmosphere, and that we have perhaps for some billions of years been in one of these currents of lower temperature, in which the process of solidification continues on a large scale, just as on a small scale it occurs on the earth's surface during north winds, and that some hot current which sooner or later may pass through our starry heaven may again bring about a gaseous distribution of matter.

This example shows that we may use our experiences of the finite only for deductions within the finite. As soon as man wishes to overstep this domain, which is opened to him by his senses and which is accessible to his knowledge, and wants to form some conception of the whole, he falls into absurdities. Either he leaves unconsidered what he has gained by experience and meditation, and then he loses himself in arbitrary and empty fancies; or he proceeds logically from the laws fo the finite and then he finally arrives at perfectly ridiculous consequences.

The example mentioned before may again serve to illustrate this. The world known to us changes. If we follow these changes according to the laws of causality, backward into the past and forward into the future, and place ourselves upon the before-mentioned physical stand-point of the nebular theory, and adopt what is known to us there as a measure, then we find stages both in the past and the future which more and more approach perfect rest, without ever reaching it altogether. But if we assume a further point of view, and suppose that heavenly bodies and systems of heavenly bodies arise and perish without end in the universe, then we find two possibilities: either, according to the materialistic conception, the successive stages are of the same value; or, according to the philosophical conception, they continually change their relative value, becoming more perfect every time, in which case the universe would in the eternal past more and more approach absolute imperfection (therefore rest), and in the eternal future absolute perfection (therefore again rest). All three conceptions are equally irrational. The first (physical) and the third (philosophical) let the world awaken from dead rest and return to it. The second (materialistic) condemns it to eternal rest, because a change which always repeats itself, means for an eternity nothing else but rest.

With space we do not fare better than with time. We naturally wish to imagine the universe as of finite extent in space and thus make it accessible to our conception. But as the space filled with matter can but everywhere be limited by more space filled with matter, we arrive at the absurd deduction that the world in its circumference is bordered by itself. But if we allow infinity to universal space, and according to our ideas of space it must be infinite, then heavenly bodies follow upon heavenly bodies without end, in different sizes, different compositions, and different stages of development. Now as size, composition, and stages of development move within finite limits, the combinations which are possible constitute of course, to our ideas, an infinitely great, but yet not an endless number. If this number is exhausted the same combinations must repeat themselves. We cannot deny this, even with the conviction that centillions upon centillions of heavenly bodies or systems of heavenly bodies would not suffice to complete the number of possible combinations. Because centillions compared to endlessness are less than a drop of water compared to the ocean. We therefore arrive at the mathematically correct, but to our reason most absurd, deduction that our earth, just as it is now, must occur several times, indeed an infinite number of times in the universe, and that also the jubilee festival, which we celebrate to-day, is celebrated just in the same way upon many other earths.

The logical consequences of this kind may be multiplied. The examples suffice to show, that our finite reason is only accessible to finite conceptions, and that, when it wishes to raise itself to conceptions of the eternal in however logical a manner, its wings become paralysed, and, like a second Icarus, before the sunny heights are reached, it falls back into the depths of finite and obscure ideas.

(*To be continued.*)

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

OXFORD.—The Physical Science Postmastership at Merton College, has been awarded to Mr. E. T. Milner, of Manchester Grammar School.

CAMBRIDGE.—Mr. J. N. Langley, B.A., of St. John's College, has been elected a Fellow of Trinity College. Mr. Langley was bracketed second in the first-class of Natural Science Tripos 1874.

EDINBURGH.—Mr. Thomas Annandale, who was assistant to the late Prof. Syme, has been appointed to the chair of Clinical Surgery in Edinburgh University, vacant by the removal of Mr. Lister to King's College, London.

UPSALA.—The *Scotsman* of Thursday last, contains a very full and interesting account of the recent Upsala celebration, evidently by one of the Edinburgh delegates. The writer, speaking of a visit he paid to one of the largest schools of Upsala, built for about 500 pupils, says:—"Here, as elsewhere in Sweden, the expense of education is wholly borne by the State. The pupils pay no fees. The building is spacious and airy, and the class-rooms and playgrounds furnished, almost to luxuriousness, with the requisites for the development of healthy minds in healthy bodies. The arrangements for the securing of the required heating and ventilation of the rooms during the long severe winters of Sweden are particularly good. Nearly every class-room is seated for about thirty pupils. Each pupil has his own little desk before him, and a chair with a back fitting comfortably to his body, and adjustable as to height so as to suit each pupil. This seat he retains during the session, so that there is no taking of places in the classes. There are several carefully-selected libraries for the pupils in the school—a marked feature of which is the number of books in English, French, and German; and there is the best proof everywhere that these volumes, which are mostly classic authors in these languages, do not lie idly on the shelves, in the number of Swedes one meets with who can converse tolerably well in one or all of these languages. But what struck us as deserving of the very warmest commendation, are the well-appointed and well-kept museums of apparatus illustrative of the simplest and most fundamental facts of natural philosophy and chemistry; well-dried mounted specimens of the common plants of the district; stuffed and otherwise prepared specimens of the Swedish fauna; large models of typical plants